Quality of Service · Part 1

Quality of Service Models

Best Effort · No QoS policies are implemented

Integrated Services (IntServ)
Resource Reservation Protocol (RSVP) is used to reserve bandwidth per-flow across all nodes in a path

Differentiated Services (DiffServ)
Packets are individually classified and marked; policy decisions are made independently by each node in a path

Layer 2 QoS Markings

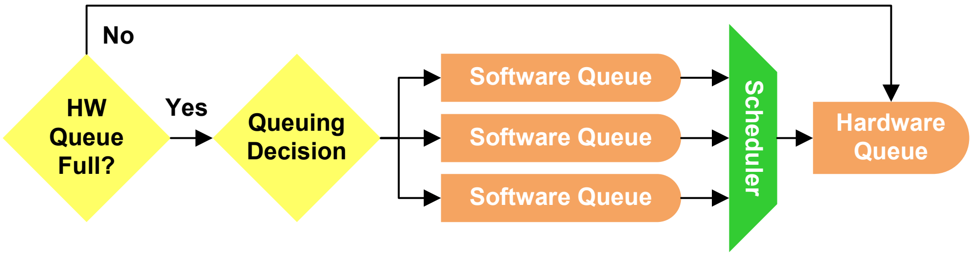
Medium	Name	Type
Ethernet	Class of Service (CoS)	3-bit 802.1p field in 802.1Q header
Frame Relay	Discard Eligibility (DE)	1-bit drop eligibility flag
ATM	Cell Loss Priority (CLP)	1-bit drop eligibility flag
MPLS	Traffic Class (TC)	3-bit field compatible with 802.1p

IP QoS Markings

IP Precedence
The first three bits of the IP TOS field; limited to 8 traffic classes

Differentiated Services Code Point (DSCP)
The first six bits of the IP TOS are evaluated to provide more granular classification; backward-compatible with IP Precedence

QoS Flowchart



Terminology

Per-Hop Behavior (PHB)
The individual QoS action performed at each independent DiffServ node

Trust Boundary · Beyond this, inbound QoS markings are not trusted

Tail Drop · Occurs when a packet is dropped because a queue is full

Policing
Imposes an artificial ceiling on the amount of bandwidth that may be consumed; traffic exceeding the policer rate is reclassified or dropped

Shaping
Similar to policing but buffers excess traffic for delayed transmission; makes more efficient use of bandwidth but introduces a delay

TCP Synchronization
Flows adjust TCP window sizes in synch, making inefficient use of a link

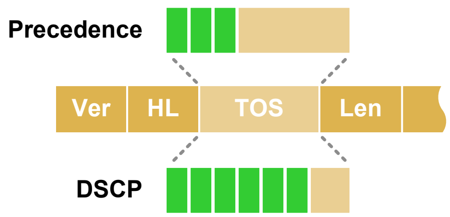
DSCP Per-Hop Behaviors

Class Selector (CS) · Backward-compatible with IP Precedence values

Assured Forwarding (AF) · Four classes with variable drop preferences

Expedited Forwarding (EF) · Priority queuing for delay-sensitive traffic

IP Type of Service (TOS)



Precedence/DSCP

	Binary	DSCP	Prec.
56	111000	Reserved	7
48	110000	Reserved	6
46	101110	EF	5
32	100000	CS4	4
34	100010	AF41	
36	100100	AF42	
38	100110	AF43	
24	011000	CS3	3
26	011010	AF31	
28	011100	AF32	
30	011110	AF33	
16	010000	CS2	2
18	010010	AF21	
20	010100	AF22	
22	010110	AF23	
8	001000	CS1	1
10	001010	AF11	
12	001100	AF12	
14	001110	AF13	
0	000000	BE	0

Congestion Avoidance

Random Early Detection (RED)
Packets are randomly dropped before a queue is full to prevent tail drop; mitigates TCP synchronization

Weighted RED (WRED)
RED with the added capability of recognizing prioritized traffic based on its marking

Class-Based WRED (CBWRED)
WRED employed inside a class-based WFQ (CBWFQ) queue

by Jeremy Stretch

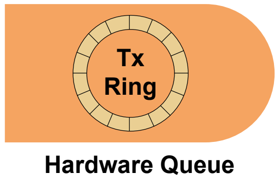
v2.0

Quality of Service · Part 2

Queuing Comparison

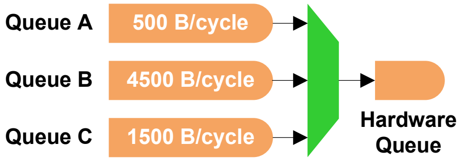
	FIFO	PQ	CQ	WFQ	CBWFQ	LLQ
Default on Interfaces	>2 Mbps	No	No	<=2 Mbps	No	No
Number of Queues	1	4	Configured	Dynamic	Configured	Configured
Configurable Classes	No	Yes	Yes	No	Yes	Yes
Bandwidth Allocation	Automatic	Automatic	Configured	Automatic	Configured	Configured
Provides for Minimal Delay	No	Yes	No	No	No	Yes
Modern Implementation	Yes	No	No	No	Yes	Yes

First In First Out (FIFO)



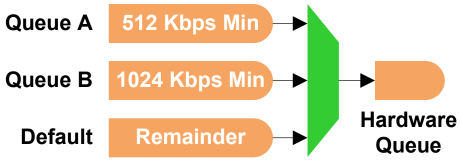
- Packets are transmitted in the order they are processed
- No prioritization is provided
- Default queuing method on high-speed (>2 Mbps) interfaces
- Configurable with the **tx-ring-limit** interface config command

Custom Queuing (CQ)



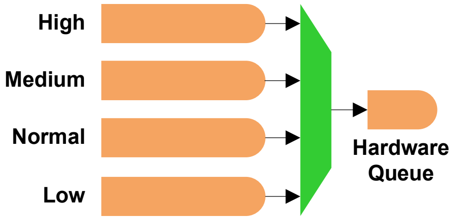
- Rotates through queues using Weighted Round Robin (WRR)
- Processes a configurable number of bytes from each queue per turn
- Prevents queue starvation but does not provide for delay-sensitive traffic

Class-Based WFQ (CBWFQ)



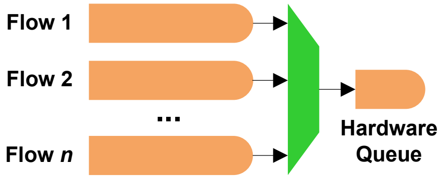
- WFQ with administratively configured queues
- Each queue is allocated an amount/percentage of bandwidth
- No support for delay-sensitive traffic

Priority Queuing (PQ)



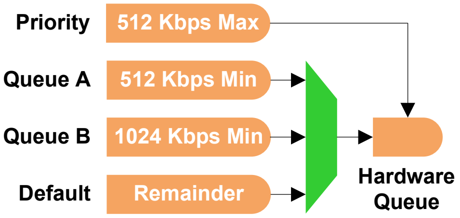
- Provides four static queues which cannot be reconfigured
- Higher-priority queues are always emptied before lower-priority queues
- Lower-priority queues are at risk of bandwidth starvation

Weighted Fair Queuing (WFQ)



- Queues are dynamically created per flow to ensure fair processing
- Statistically drops packets from aggressive flows more often
- No support for delay-sensitive traffic

Low Latency Queuing (LLQ)



- CBWFQ with the addition of a policed strict-priority queue
- Highly configurable while still supporting delay-sensitive traffic

LLQ Config Example

Class Definitions

```
! Match packets by DSCP value
class-map match-all Voice
 match dscp ef
!
class-map match-all Call-Signaling
 match dscp cs3
!
class-map match-any Critical-Apps
 match dscp af21 af22
!
! Match packets by access list
class-map match-all Scavenger
 match access-group name Other
```

Policy Creation

```
policy-map Foo
 class Voice
  ! Priority queue policed to 33%
  priority percent 33
 class Call-Signaling
  ! Allocate 5% of bandwidth
  bandwidth percent 5
 class Critical-Apps
  bandwidth percent 20
  ! Extend queue size to 96 packets
  queue-limit 96
 class Scavenger
  ! Police to 64 kbps
  police cir 64000
   conform-action transmit
   exceed-action drop
 class class-default
  ! Enable WFQ
  fair-queue
  ! Enable WRED
  random-detect
```

Policy Application

```
interface Serial0
 ! Apply the policy in or out
 service-policy output Foo
```

LLQ Config Example

```
show policy-map [interface]
Show interface
show queue <interface>
Show mls qos
```